MEDICINAL USE OF CARAPA GUIANENSIS (ANDIROBA) – AN INTEGRATIVE REVIEW

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Ivaniro Rodrigues da Costa Neto[1], Matheus da Silva Rodrigues[2], Yuri Alefh Saraiva Dias[3], William de Souza Ferreira[4], Jeovanna Brito de Moraes[5], Fabrício Viana Pereira Lima[6] and Fabricio Mesquita Tuji[7]

ABSTRACT

The study of teacher education and training for the effective use of technology, including artificial intelligence, is imperative today, as it not only redefines pedagogical practices, but also shapes the future of education, empowering educators to skillfully navigate an ever-evolving educational landscape. In this scenario, this article critically examines teacher training for the effective use of digital technologies, focusing on the growing relevance of artificial intelligence in contemporary education. Through an innovative approach, the text explores training strategies that go beyond mere technical proficiency, highlighting the importance of digital and data literacy, as well as harmonious collaboration between educators and artificial intelligence. Ethical challenges, humanistic considerations and strategies for evaluating the effectiveness of technology training are discussed. By addressing barriers and proposing strategies to overcome them, the article concludes the discussion with reflections on future perspectives, outlining an educational horizon where technology and pedagogy converge to promote more efficient and innovative learning.

Keywords: Teacher Training, Educational Technology, Artificial Intelligence, Digital Literacy.

[1] Specialist, Master and Doctoral Student, Graduate Program in Dentistry, Federal University of Pará, Belém, Pará, 66073-005, Brazil.
E-mail: dr.ivaniro@gmail.com
[2] Bachelor of Dentistry, University of Amazonia, Ananindeua, Pará, 67113-901, Brazil.
[3] MSc and Doctorate Student, Graduate Program in Genetics and Molecular Biology, Federal University of Pará, Belém, Pará, 66073-005, Brazil.
[4] Specialist and Master's student, Graduate Program in Dentistry, Federal University of Pará, Rua Augusto Corrêa, 1, Belém, Pará, 66075-110, Brazil.
[5] Specialist and Master's Degree, Graduate Program in Dentistry, Federal University of Pará, Rua Augusto Corrêa, 1, Belém, Pará, 66075-110, Brazil.
[6] Specialist, Master and Doctoral Student, Graduate Program in Dentistry, Federal University of Pará, Belém, Pará, 66073-005, Brazil.
[7] Dr., Professor, Graduate Program in Dentistry, Federal University of Pará, Rua Augusto Corrêa, 1, Belém, Pará, 66075-110, Brazil.

INTRODUCTION

GENERAL ASPECTS

Andiroba (*Carapa guianensis)* is a tree widely distributed in the Amazon region, which has been the subject of study due to its medicinal properties (Fonseca *et al*., 2024). In this context, the review of the literature on the medicinal use of andiroba provides a comprehensive overview of the various therapeutic applications of this plant species (Firmino *et al*., 2019). The importance of scientific research and traditional knowledge about the pharmacological properties of andiroba for the development of new drugs and for the practice of phytotherapy deserves to be highlighted (Henriques & Penido, 2014). Therefore, this review aims to gather and synthesize the available knowledge on the medicinal use of andiroba, aiming to contribute to the advancement of research and to the insertion of this plant in clinical practice.

RELATED STUDIES

Botany and Ecology of *Carapa Guianensis*

Carapa guianensis, popularly known as andiroba, is a large tree found in the Amazon region (Matsui *et al*., 2014). It belongs to the Meliácea family and can reach up to 40 meters in height, with a trunk that reaches 1 meter in diameter. Its flowers are white and small, grouped in inflorescences (Jesus *et al*., 2017). Andiroba is a heliophilous species, that is, it needs a lot of sunlight for its development. Its dispersal is done through seeds, which are disseminated mainly by water (Milhomem-Paixão*, et al.,* 2016).

The andiroba, belonging to the Meliaceae family, is native to the Amazon region and can be found in other areas, such as southern Central America, Colombia, Venezuela, Suriname, French Guiana, Brazil, Peru, Paraguay and the Caribbean Islands. In Brazil, it is distributed in the North (Acre, Amazonas, Amapá, Pará) and Northeast (Maranhão) regions. The plant stands out for its pharmacological properties, with active components present in flowers, leaves and stems, although the oil extracted from the seeds by pressing has shown the best medicinal effects.

Chemical Composition and Pharmacological Properties

The seeds, bark, and leaves of andiroba (*Carapa guianensis Aubl*) contain bioactive compounds, such as limonoids, terpenes, and flavonoids (Pereira da Silva *et al*., 2023). Studies show that the plant has anti-inflammatory, analgesic, antimicrobial, antiparasitic, and antioxidant properties. The oil extracted from its seeds has a yellowish, thick consistency and bitter taste due to the presence of Meliacin, being rich in fatty acids such

as oleic, linoleic and palmitic, which give it emollient and healing properties (Milhomem-Paixão *et al*., 2016; Gomes *et al.,* 2023).

This oil is composed of saponifiable (95%) and unsaponifiable (2 to 5%) substances, especially fatty acids, which act as catalysts in the healing process, stimulating cell proliferation, collagen production and presenting antimicrobial, anti-inflammatory and antioxidant actions. Studies indicate that andiroba oil is effective in several therapeutic purposes, as a natural repellent, in dermatological treatments and in fighting inflammation. Its antibacterial, healing, antiparasitic, insecticidal, antiallergic, and antinociceptive activity is widely recognized (Gomes *et al.,* 2023).

Traditional Use of Andiroba in Folk Medicine

The traditional use of andiroba in folk medicine is widely recognized in the Amazon, where local communities have for generations used the plant's seeds and oil to treat a variety of conditions (Araújo-Lima *et al.,* 2018). Among the most common uses are the treatment of inflammation, muscle pain, rheumatism, bruises, wounds, and insect bites (Pereira da Silva *et al.,* 2023). In addition, it is common to use andiroba oil as an insect repellent, infection prevention, and for dermatological purposes, such as skin hydration and eczema treatment (Milhomem-Paixão, *et al.,* 2016; Pereira da Silva *et al.,* 2023). Tradition and the transmission of empirical knowledge from generation to generation have kept alive the practices of using andiroba in folk medicine (Gomes *et al.,* 2023).

These findings corroborate the traditional use of andiroba in complementary medicine, reinforcing its potential as a relief of acute and chronic pain (Soares *et al*., 2020; Gomes *et al*., 2023).

Antimicrobial and Antifungal Activities

This section presents a review of the scientific studies that investigated the biological activity of *Carapa guianensis Aubl*, highlighting the antimicrobial and antifungal action. Studies have shown the effectiveness of andiroba in fighting bacteria and fungi, which reinforces its therapeutic potential (Melo *et al.,* 2021). In addition, the different tests conducted to evaluate these activities will be discussed, providing a comprehensive overview of the findings and challenges in this area of research (Silva *et al.,* 2021).

Scientific studies have shown that *Carapa guianensis*, popularly known as andiroba, has antimicrobial and antifungal activity (Soares *et al.,* 2020). Several extracts obtained from the seeds and oil of this plant have shown efficacy against pathogenic bacteria and fungi, including *Staphylococcus aureus, Escherichia coli,* and *Candida albicans* (Oliveira *et*

al., 2018). The antimicrobial and antifungal properties of andiroba have aroused interest in the search for new therapeutic agents, especially as an alternative to conventional treatments, and may contribute to the development of new drugs with action against bacterial and fungal infections (Jesus *et al.,* 2017; Nagatomo *et al*., 2022).

Anti-inflammatory and Analgesic Activities

The bioactives present in andiroba oil, such as limonoids and triterpenes, are known to inhibit pro-inflammatory mediators, resulting in effective therapeutic effects in the treatment of inflammatory and painful conditions (Henriques and Penido, 2014). Among these compounds, tetranortriterpenoids (TNTP) stand out, conferring analgesic and anti-allergic properties, which explains the significant pain relief in patients treated with the oil (Henriques and Penido, 2014; Ferraris *et al*., 2011).

In the randomized controlled clinical study conducted by Soares *et al*. (2020), which compared the efficacy of andiroba oil in orabase with low-level laser therapy in the treatment of oral mucositis (OM), noted that the andiroba treated group had a lower symptom severity between the fourth and sixth day, as well as a significant reduction in pain between the second and fourth day, compared to the group treated with laser. On the eighth day, all patients in the andiroba group were pain-free, while the laser group still reported symptoms until the eleventh day, evidencing the superiority of andiroba oil as an anti-inflammatory and analgesic agent.

Experimental studies with rats also reinforce the therapeutic potential of andiroba oil, demonstrating that it inhibits inflammatory mediators such as TNF-α and IL-1β, through the inhibition of nuclear factor Kb (NFKb) (Penido *et al*., 2006). As these mediators are present in all phases of oral mucositis, the effectiveness of the oil in the treatment becomes evident. In addition, research with Syrian hamsters has confirmed that andiroba oil accelerates the healing process and reduces the severity of mucositis, further strengthening the evidence for its therapeutic potential (Wanzeler *et al*., 2017).

Antioxidant Activities

Studies on the antioxidant activities of *Carapa Guianensis* have revealed promising results, demonstrating that the extracts of this plant have the ability to fight the damage caused by free radicals in the body (Araújo-Lima *et al.,* 2018). The presence of phenolic compounds and flavonoids in andiroba has been shown to be effective in neutralizing free radicals, giving it protective potential against oxidative stress (Araújo-Lima *et al.,* 2018). In addition, andiroba has shown the ability to increase the levels of antioxidant enzymes, such

as superoxide dismutase and catalase, contributing to the prevention of diseases associated with oxidative stress, such as premature aging and chronic diseases (Araújo-Lima *et al.,* 2018).

Antiparasitic Activities

Scientific research points to the effectiveness of andiroba in combating parasites, such as *Leishmania*, which causes leishmaniasis (Oliveira *et al.,* 2018; Fonseca *et al.,* 2024). In addition, studies demonstrate the antiparasitic potential of andiroba against other protozoa and helminths, evidencing its relevance in the development of new treatments for parasitic diseases (Farias *et al.,* 2009). The antiparasitic activity of andiroba has been attributed to the presence of compounds such as limonoids and terpenes, which have positive effects on the control and prevention of parasitic infections, highlighting the therapeutic potential of this plant in traditional and alternative medicine (Oliveira *et al.,* 2018).

Healing and Dermatological Activities

Andiroba oil has the ability to accelerate the healing of wounds and skin lesions, in addition to having anti-inflammatory activity, which makes it an effective treatment for dermatitis, eczema, and psoriasis (Silva *et al.,* 2021; Fonseca *et al.,* 2024). In addition, Andiroba is rich in compounds that stimulate collagen production, contributing to skin regeneration and scar prevention (Morikawa *et al.,* 2018). Its antioxidant and antiseptic effects also aid in maintaining skin health, making it a promising option for treating various dermatological conditions (Wanzeler *et al.,* 2018).

Anticancer Activities

More recent research has investigated the possible anticancer effects. The liquid taken from andiroba seeds has bioactive limonoids that have anti-inflammatory and anti-allergic properties (Fonseca *et al.,* 2024). Fonseca et al., (2024) point out that these limonoids have demonstrated induction of apoptosis in stomach cancer cells and antioxidant properties that protect DNA. The positive effect of the oil in decreasing the severity of oral mucositis and pain in children undergoing chemotherapy treatment was also proven by Soares et al. (2021). Various extraction methods result in varying oils in antioxidant activities and potential genotoxic effects (Araújo-Lima *et al.,* 2018). Although certain extraction methods can generate oils with mutagenic potential, cold-pressed oil is considered the safest option for use (Araújo-Lima *et al.,* 2018).

Toxicity and Safety of Use of Andiroba

The evaluation of genotoxicity, by means of the comet assay carried out by Gomes *et al*. (2023), revealed that treatment with andiroba oil did not present DNA damage. These results corroborate a study with Wistar rats, which also did not report toxicity or DNA damage associated with the use of andiroba oil, reinforcing its therapeutic feasibility (Costa-Silva *et al*., 2007).

The active components of the oil, especially the limonoids, have demonstrated, in in vivo studies, anti-inflammatory and anti-allergic properties, without significant cytotoxic or genotoxic effects (Silva *et al*., 2023). Despite the promising results, more studies are needed to fully understand the safety and efficacy of andiroba in various clinical applications.

METHODS

The literature review methodology used in this work was based on the search and selection of relevant studies related to the medicinal use of *Carapa guianensis*. Specific inclusion criteria were used, such as publications in Portuguese and English, studies with humans and animals, clinical trials, and experimental studies. Access to several databases was part of the search strategy, including PubMed, Scopus, and SciELO, using terms such as 'Carapa guianensis', 'andiroba', 'pharmacological activities', among others. In addition, the search was expanded to include studies older than 10 years. This decision is based on the scarcity of research focused on the dental environment. This approach aimed to perform a critical analysis of the oldest and most current information. After selecting the studies, the data were analyzed and synthesized in order to identify the main findings and trends in the scientific literature on the subject. Possible limitations and potential biases found during the review were discussed, aiming to provide a critical and objective analysis of the included studies.

STUDY SELECTION CRITERIA

The criteria for selecting studies for this literature review included the relevance of the study to the medicinal use of *Carapa guianensis*, methodological quality, publication in indexed scientific journals, publication period, and availability of the full text. Studies that addressed botany, ecology, chemical composition, pharmacological properties, traditional use, biological activity, and the potential of andiroba in medicine were considered. In addition, systematic reviews, meta-analyses, clinical trials, in vitro and in vivo studies, as well as case reports were included, as long as they were in accordance with the proposed

themes. The search was carried out in multidisciplinary and specialized scientific databases, without language restrictions, with emphasis on studies carried out in Brazil, due to the relevance of andiroba in popular and traditional medicine in the country.

DISCUSSION

CRITICAL ANALYSIS

The pharmacological properties of *Carapa guianensis* (andiroba) oil were highlighted in the reviewed studies. The reduction in leukocyte infiltration, increased cytokine activity, and improved fibroblast recovery are responsible for the anti-inflammatory and wound healing effects (Fonseca *et al.,* 2024). According to Soares *et al.* (2020), it has been proven that the oil is more effective than low-level laser therapy for relieving the severity and pain of oral mucositis in children with cancer. The active limonoids in andiroba oil have anti-inflammatory, anti-allergic, and anticancer potential properties without significant cytotoxicity or genotoxicity effects (Silva *et al.,* 2023). However, extraction techniques directly influence the characteristics and safety of the oil. According to Araújo-Lima *et al.* (2018), cold-pressed oil showed greater antioxidant power and offered more safety than hot-pressed oils, which suggests mutagenic and genotoxic potential. These findings corroborate the ancient medicinal practices of andiroba, highlighting the importance of further studies on extraction techniques and clinical uses to consolidate safety and efficacy.

LIMITATIONS AND POTENTIAL BIASES

When reviewing the literature on the medicinal use of *Carapa Guianensis*, it is important to consider the potential limitations and biases that may impact the validity of the results. Some of the potential limitations include the lack of standardization in the preparation and dosing methods of andiroba, the variation in the quality of the raw materials used, the possibility of publication bias, the scarcity of controlled clinical studies, and the presence of conflicting results. Additionally, it is crucial to be aware of any specific biases that may have influenced the results of the studies, such as selection bias, performance bias, and detection bias. By taking these aspects into account, it is possible to have a more critical and balanced view of the overall picture of the available evidence on the use of andiroba for medicinal purposes

CONTRIBUTIONS TO CLINICAL PRACTICE AND RESEARCH IN PHYTOTHERAPY

The contributions of *Carapa Guianensis* to clinical practice and research in phytotherapy are significant, since its compounds have demonstrated relevant

pharmacological activities, such as antimicrobial, anti-inflammatory, analgesic, antioxidant, antiparasitic, healing and anticancer. These properties open up new opportunities for the development of herbal medicines, meeting the demand for natural and effective alternatives. In addition, andiroba can also contribute to studies aimed at the sustainable exploitation of biodiversity, as well as to the appreciation of traditional knowledge. In this way, research with *Carapa Guianensis* has the potential to positively impact clinical practice and research in phytotherapy, offering new therapeutic perspectives and promoting environmental conservation.

CONCLUSION

We conclude that *Carapa guianensis*, popularly known as Andiroba, has great therapeutic potential due to its antimicrobial, anti-inflammatory, antioxidant, antiparasitic, healing and anticancer activities, in addition to its traditional use in folk medicine. However, further studies are needed to evaluate the safety of use and toxicity, as well as to explore its potential in clinical practice. The literature review also highlights the importance of considering *Carapa guianensis* as a promising option for the development of new herbal medicines and highlights the relevance of sustainable harvesting practices and the preservation of the species.

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